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Seasonal Quality Premiums for Wheat: a Case Study for Northern Germany

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Abstract

Seasonal variations of the price premium for bread and feed wheat indicate opportunities to profitably adjust grain marketing strategies of farmers that harvest (and store) both qualities. We estimate the seasonal pattern of price premiums on the German market using a vector error correction approach, which accounts for multivariate autoregressive conditional heteroscedasticity of the error terms. Results indicate a significant downward trend for the seasonal premium, with the trend's magnitude depending on the average quality of harvested wheat. If farmers separately store both bread and feed wheat, they should tend to sell bread wheat before they sell feed wheat, particularly in years of low average wheat qualities.

Introduction

Theoretical and empirical studies on optimizing farmers' marketing of grain generally use dynamic optimization techniques to find the optimal selling date for grain stocks in a season (Berg, 1987; Blakeslee and Lone, 1995; Blakeslee, 1997; Fackler and Livingston, 2002; Loy and Piniadz, 2009). These models assume a homogenous grain quality for all volumes marketed. In addition to the literature on optimal grain marketing, a number of papers analyse the price relationship between various qualities of grain and show significant price differences, for instance between bread and feed wheat (e.g. Bale and Ryan, 1977; Larue, 1991; Uri and Hyberg, 1996; Espinosa and Goodwin, 1991; Parcell and Stiegert, 2003). Quality characteristics such as the protein content and the falling number have significant impact on the price relationship, which may affect the production and marketing of wheat, particularly when the price relationship exhibits dynamic behavior over the marketing season.[1]

The purpose of this paper is to estimate the magnitude of the seasonal pattern of the price premium and to explore, from a farmers' perspective, the marketing opportunities that follow from it. We thus contribute to the literature on estimating wheat (quality) price premiums and on optimal wheat (grain) marketing. To the best of our knowledge, this paper represents a first attempt to derive managerial implication from the seasonal pattern of the price premium. Methodologically, we employ a multivariate approach that considers the specific time series properties of the processes under study. We estimate a vector error correction model (VECM) with multivariate autoregressive conditional heteroscedasticity (MGARCH).

We apply our model to data from Northern Germany, where the marketing season starts in August after harvest and ends in July of the following year. Collecting weekly producer prices of bread and feed wheat and aggregating those data for the past seventeen years (see Figure 1) clearly indicates a falling trend for the price premium during the marketing season. The average premium starts at about ten Euros per ton and drops to about four Euros per ton towards the end of the season. Considering the average price level of feed wheat, this change of about six Euros per ton during the season accounts for approximately five percent of the average feed wheat price, or about 12 percent of the contribution margin per ha over the 1994/95 to 2010/11 period. The seasonal behavior of the price premium implies that farmers should sell bread wheat before they sell feed wheat.

[1] Karaman et al. (2009) first mentioned potential seasonal dynamics of the quality premium.

– Insert Figure 1 about here –

We proceed as follows. First, we develop a theoretical model to explain the negative seasonal trend of the price premium. Second, following a brief literature review, we derive the model specification and present the data under study. Third, we estimate the seasonal pattern of the price premium and its volatility. The final model specification includes two quality factors (protein content and falling number), a demand indicator (wheat used for human consumption), and an interaction term between a seasonal trend and the falling number variable. Finally, we summarize our findings and discuss implications for the seasonal marketing of wheat.

Theory

Similar to many other agricultural commodities, wheat is a heterogeneous good that differs across space, time and quality (Goodwin and Smith, 2009). Indeed, the analysis of wheat quality premiums is frequently discussed in the literature. Prominent quality characteristics of wheat are the protein content, the falling number, the test weight, the share of foreign matters, the share of shrunken and broken kernels, etc. According to these characteristics, different wheat lots belong to various classes. On the German wheat market, bread and feed wheat are the most prominent classes. The classification sets standards for protein content, falling number, sedimentation value, test weight and moisture content. Protein content, test weight and moisture content are partly controlled by a farmer's practice; the weather conditions predominantly influence the falling number in particular, while weather conditions during the harvest season determine the quality of the harvested wheat (Hollins et al., 2006). The minimum quality requirements of bread wheat are a protein content of 12 percent, a falling number of 220 seconds, a sedimentation value of 30, a test weight of 76 kg per hectoliter, and a moisture content of 14.5 percent. Except for the moisture content, undercutting these minimum qualities leads to downgrading; all downgraded wheat is classified as feed wheat.[2]

Grain farmers in Northern Germany mainly produce bread-quality wheat. However, because of bad weather conditions or poor practices, not all harvested wheat fulfills the quality requirements; thus, farmers end up with feed wheat to some extent. Figure 1 shows that the price differential between bread and feed wheat follows a significantly falling trend throughout the season. From interviews with market experts, we obtain some ideas to explain this attribute of the seasonal pattern of the quality premium. The first argument relies on fixed contracts between millers and traders. For the second argument, we assume that towards the end of the season, due to a low supply of feed wheat, the feed industry starts using bread wheat or imports feed wheat.

In the following, we develop these arguments in detail and discuss the implication for the marketing of wheat. Following the first argument, grain millers sign contracts with food retail chains that cover most of their entire season's (annual) production. To hedge these contracts, the milling industry signs contracts with grain traders long before harvest; grain traders hedge their obligations with the millers by contracting bread wheat from framers. In years with unfavorable weather conditions, a significant amount of the contracted wheat does not meet the quality requirements of bread wheat. Figure 2 illustrates the supply and demand of farmers and grain traders over the season for a year with unfavorable weather conditions during the harvest. The season is modeled by a period 1 (start of the season) and a period 2 (end of the season). Germany has a significant wheat surplus of 20 to 50 percent of the annual production (AMI, various issues).[3] Since the McSharry-Reform in 1992 and the agreement of GATT-Uruguay-Round in 1993, the EU has lifted many external trade regulations for wheat. We model the Northern German wheat market as a small, liberal open economy.

[2] A protein content of more than 13 percent, a falling number of more than 250 seconds and a sedimentation value of more than 40 defines extra quality wheat. Bread and feed wheat qualities are dominant on the German market.

[3] For Northern Germany, these Figures are likely to be higher. About one-third of the wheat harvested in Germany comes from the Northern territory, where only 17 percent of the population lives.

Transportation (transaction) costs for wheat are significant and thereby regional prices range between Fob and Cif-prices (e.g. $Cif^B > Fob^B$).[4]

– Insert Figure 2 about here –

Bread wheat is of higher quality than feed wheat, and thus prices of bread wheat exceed feed wheat prices (e.g. $Cif^B > Cif^F$) and due to storage costs, prices are higher at the end of the season (e.g. $Cif^{B+} > Cif^B$). The demand of bread wheat at the beginning of the season is fixed due to contracts between millers and grain traders $\left(Q_{D1}^B\right)$. If the contracted volume with farmers does not meet the quality requirements for bread wheat, the supply of bread wheat falls short $\left(Q_{S1}^B\right)$ at the start of the season. Some of the contracted volume is downgraded to feed wheat $\left(Q_{S1}^F\right)$ and sold immediately to the feed industry $\left(Q_{D1}^F\right)$ or exported $\left(Q_{S1}^F - Q_{D1}^F\right)$.[5] Grain traders must fill the gap between Q_{D1}^B and Q_{S1}^B by either importing bread wheat or procuring bread wheat from farmers who have stored their harvest wheat. Farmers who put wheat in stock will expect a certain profit from storage. When grain traders want to procure bread wheat from these farmers at the start of the marketing season, they must compensate farmers for their expected profits from storage. Expectations about storage profits likely differ between farmers; thus, compensations will increase with the volume procured by grain traders. In Figure 1, traders need to pay P_1^B to fill the gap between Q_{D1}^B and Q_{S1}^B. The procurement in the region is still cheaper than importing wheat from other more distant regions. The price of feed wheat is thus at P_1^F. The domestic demand of the feed industry in the case of bad weather is smaller than supply at start of the marketing season; thus, the Fob-price (Cif^F) matches the equilibrium price. All farmers who have bread wheat contracts with grain traders will deliver the contracted volume.[6] If the delivered wheat does not match the quality requirements, the wheat will not return to the farm due to transaction costs. Farmers sell the downgraded volumes and receive the price of feed wheat. Thus, the price premium at the start of the season is at M_1. The maximum premium at the beginning of the season would be Cif^B minus Fob^F.

Following the second argument, the feed industry has a continuous demand similar to the milling industry but shows a more elastic demand compared to millers due to the number of alternative raw materials. The feed industry does not contract its demand in advance, so they can immediately react to changes in input prices at all times. While millers can only use bread wheat, the feed industry can use maize, barley, soybeans and many other components to produce feed of the same quality. In years with a high supply of feed wheat, the price at the beginning of the season can drop to the Fob-price level; towards the end of a season, the price of feed wheat may increase towards the Cif-price. In Figure 2 only bread wheat that is either exported or used by the feed industry is available at the end of the season. Thus, the price for bread wheat is P_2^B. If the supply of bread wheat is sufficient to match the demand by the feed industry, the price for feed wheat is slightly lower because bread wheat has still some higher quality characteristics that matter for the feed industry, for example the protein content. The premium at the end of the season is at M_2. The minimum price premium at the end of the marketing season is Fob^{B+} minus Cif^{F+}.[7] These arguments can explain the observed development of the seasonal price premium between bread and feed wheat as shown in Figure 1.

[4] Cif: cost insurance freight. Fob: free on-board. We use superscripts B and F to indicate bread and feed wheat.
[5] Transaction costs are likely too high to return the wheat to the farm and store it to sell the wheat later.
[6] Grain traders test the quality of wheat after delivery to their production site.
[7] Technically the Cif-price for feed wheat could be higher than the Fob-price for bread wheat. In this case bread wheat would be used as feed wheat until prices equalize. At minimum, the price difference can be zero.

Model Specification and Data

Many studies on the impact that wheat quality has on prices use hedonic (pricing) models to test the effects of quality characteristics on annual domestic or international prices (Bale and Ryan, 1977; Larue, 1991; Uri and Hyberg, 1996; Espinosa and Goodwin, 1991; Parcell and Stiegert, 2003). Bale and Ryan (1977) analyze the impact of the protein content on the price ratio between various wheat classes, and find a mainly significant positive impact. Larue (1991) uses Fob prices for the US, Canada and Australia, and the results show that most quality characteristics have no significant impact on average prices. The protein content is the only exception, again with a positive coefficient.[8] Uri and Hyberg (1996) employ shipment data of US wheat exports to examine grain quality factors. Although a number of factors appear to be significant, market traders do not use many of these measures. The protein content has a significant positive impact on transaction prices. Espinosa and Goodwin (1991) also use a hedonic price model for regional wheat prices in Kansas. Total defects, protein and moisture content are found to have significant effects on prices. Parcell and Stiegert (2003) analyse deviations of regional wheat prices from regional averages. Quality characteristics and district dummies significantly explain some of the price deviations. The most important quality characteristic is the protein content.[9] Karaman et al. (2009) investigate the impact of quality factors on the Turkish wheat market, and find mixed results for different regions in Turkey. The authors mention that there may be a seasonal impact of the quality premium, which they do not investigate conclusively. Goodwin and Smith (2005, 2009) use a VAR model for regional prices of different classes of wheat in the US, and test the impact of protein availability using a threshold modeling approach. Price relationships appear to differ depending on the size of the deviation in the availability of protein sources in the market.[10]

Hollins et al. (2006) investigate the annual price premium between bread and feed wheat for the UK from 1982 to 2000 based on a model of supply and demand, stocks and productions of feed, bread wheat and substitutes. The protein content, the specific weight and the falling number reflect quality characteristics. These authors use a model selection procedure provided in the GenStat software to identify the best specification. According to the procedure, a model that uses livestock numbers as an indicator for feed wheat demand, wheat stocks and the falling number is the preferred model. The falling number has a negative sign, indicating that the premium increases in years with unfavorable weather conditions, and thereby low falling numbers (Hollins et al., 2006).

We combine the studies by Karaman et al. (2009), Goodwin and Smith (2009), and Hollins et al. (2006) by looking at the premium between bread and feed wheat using a VECM model and investigating the seasonal pattern of the bread-feed-wheat-price-relationship. We collect regional producer prices for Northern Germany for both qualities. Prices are reported weekly by a public extension service, prices come from telephone interviews with local grain traders. The period of observation is from 1994 to 2011; the number of observations is 905.[11] Prices are free of carriage ex elevator for the federal state of Schleswig-Holstein (Landwirtschaftskammer Schleswig-Holstein, 2012). Figure 3 shows the bread and feed wheat price series under study.

– Insert Figure 3 about here –

[8] Similar studies are presented by Veeman (1987), Wilson (1989), and Hennings and Martin (1989).

[9] The test weight appears to be significant; however, the sign is opposite to expectations.

[10] We take up this point by measuring quality variables that characterize the availability of protein in the market under study.

[11] We also use another data set of wholesale price quotations at the port of Hamburg, which is the major exporting port location. The weekly prices are collected by a commission of local traders (GRAIN TRADERS ASSOCIATION OF THE HAMBURG EXCHANGE, 2012) and cover August 1999 to December 2011 (n=645). All results reported here are very similar between both data sets. The results for the second data set can be obtained from the authors upon request.

Weekly prices of bread (feed) wheat in Schleswig-Holstein vary between 90 (84) and 274 (244) Euros per metric ton from 1994 and 2011 (Table 1). Unit root tests indicate non-stationary behavior, and bread and feed wheat prices are co-integrated. However, the long-term slope coefficient is significantly different from one. Hence, we do not model the price premium assuming a slope coefficient of one, but estimate a VECM for bread and feed wheat prices that includes quality characteristics and indicators for the availability of both qualities. Following the literature, we employ the protein content and the falling number as the main drivers of the price premium. The protein content measures the average protein content of the same samples taken during the harvest period. High protein contents indicate a higher feed value and therefore lead *ceteris paribus* to a lower price premium between bread and feed wheat; high protein content also indicates a high availability of wheat matching the protein quality characteristic of bread wheat, which also tends to lower the margin. A low falling number indicates a low (high) availability of bread (feed) wheat, particularly in the beginning of the marketing season, which leads to a higher price premium. The variable falling number measures the percentage of samples taken during harvest in the (Northern Germany) region that fail to match the falling number criterion of bread wheat. The Max-Rubner Institute for nutrition and food produces both statistics and publishes them in the Annual Grain Statistics (MRI, various issues). We also consider the market demand of bread wheat by the demand of quality wheat for human consumption. A high demand for bread wheat leads to a higher price premium between bread and feed wheat. We collect this data from the Annual Report of ZMP and AMI (ZMP, AMI, various issues).

The absolute values of the protein content $\left(Z_t^1\right)$, the falling number $\left(Z_t^2\right)$for the respective annual harvest, and the annual demand of bread wheat $\left(Z_t^3\right)$ are included as deterministic variables in order to investigate their influence on the price relationship. As shown in Figure 1 we introduce a weekly seasonal trend $\left(ST_t\right)$ and seasonal dummies on a monthly basis to verify regular changes of the price premium over the season. Because Figure 4 shows that seasonal trends differ significantly between years, we introduce an interaction term between the seasonal trend and the falling number variable $\left(ST_t \cdot Z_t^2\right)$. We also tested an interaction between the seasonal trend and the protein content, but this coefficient is not statistically significant. Also, the seasonal dummies and the seasonal trend are not statistically significant. The same testing procedure is applied to the variance equation for which a seasonal trend is the only remaining statistically significant deterministic component in both variance equations.

– Insert Figure 4 about here –

The final model specification includes two quality factors (protein content and falling number), a demand indicator (wheat used for human consumption), and an interaction term between a seasonal trend and the falling number variable. Equation 1 captures the vector error correction specification of the price premium model.

$$\mathrm{VECM:}\ \Delta P_t = \Pi P_{t-1} + \Upsilon Z_{t-1}^{1,2,3} + \Psi Z_{t-1}^2 ST_{t-1} + \sum \Gamma_i \Delta P_{t-1} + u_t \qquad (1)$$

To consider conditional heteroscedasticity of the error term, we add a multivariate GARCH (MGARCH) component to VECM (VECM MGARCH). We use a restricted BEKK (Baba-Engle-Kraft-

Kroner) specification, which excludes cross correlations over the volatility equations.[12] Further, the variance equations include a deterministic seasonal trend variable $\left(\mathrm{ST}_t\right)$ (see Equation 2).

$$\mathrm{MGARCH}: \ \Omega_t = \mathrm{CC}' + \mathrm{A}' \mathrm{u}_{t-1} \mathrm{u}'_{t-1} \mathrm{A} + \mathrm{B}' \Omega_{t-1} \mathrm{B} + \Upsilon \mathrm{ST}_t \tag{2}$$

Table 1 shows the descriptive statistics for all variables. The protein content and the falling number indicate similar average values, but the variation is much bigger for the falling number variable; the coefficient of variation is almost 100 percent. The price premium is at 7.6 Euro per ton, and shows significant variation between a minimum at a slight negative value and a maximum of 44 Euro per ton.

– Insert Table 1 about here –

Estimation Results

For estimating Equation 1, the optimal lag length of the price series and the respective price relationships under investigation are determined using Akaike (AIC), Schwarz's Bayesian (BIC) and Hanan-Quinn (HQ) Information Criteria, as well as likelihood-ratio tests (LR). The tests indicate a lag length of seven lags at maximum. For this lag length no autocorrelation of the error term appears.[13] Feed and bread wheat prices indicate co-integration. The test results become even stronger when the long-run price relationship includes the quality factors described above.[14] Due to these properties of the data generating process, a VECM is an adequate model specification. However, the error term indicates conditional heteroscedasticity. To consider autocorrelated conditional heteroscedasticity (ARCH), we employ a VECM-MGARCH(1,1) model.[15] We also include a seasonal trend in the variance equations.[16] Errors in the final estimation model are neither autocorrelated nor do they show ARCH behavior. The errors are distributed non-normal; the distribution of the errors, however, is symmetric with a higher probability of smaller values than for normally distributed errors (see Figure 5). Hence, by employing standard t Tests we may underestimate the significance of variables. Nonetheless, the results are asymptotically valid (Davidson and MacKinnon, 2004: 150 ff.).[17]

– Insert Figure 5 about here –

[12] See Serra et al. (2011) for more details of the specification. Off-diagonal elements of matrices A and B are zero. The interpretation of matrices A, B, and C in Equation 2 and their relationships to the estimated coefficients of the MGARCH process are detailed in the Appendix of the paper by Serra et al. (2011: 280).

[13] We use Ljung–Box tests up to 14 lags. For all specifications, we cannot reject the null hypothesis of no autocorrelation.

[14] We use Engle-Granger and Johansen procedures. Both prices are clearly non-stationary of order I(1) and the residuals of the co-integrating regression are stationary. For the Johansen-procedure co-integration is clearly indicated when we consider the seasonal trend as an independent variable.

[15] We use the Lagrange Multiplier test proposed by Engle (1982) to test for ARCH effects.

[16] We first include the same independent variables in the variance equation as in the long-run relationship (mean equation). We drop all variables that are not significant, and double-check the exclusion of variables by employing information criteria (AIC, BIC, and HQ). This process leaves the seasonal trend as the only independent variable in the variance equation.

[17] For asymptotically valid t and F Tests we only need to assume an identically independently distributed (IID) error term, not a normal distribution (Davidson and MacKinnon, 2004: 150).

Table 2 presents the estimation results starting with the long-run linear price relationship, while the estimates for the dynamic adjustments follow below. At the bottom of Table 2 the estimates for the MGARCH model are presented. The long-run relationship indicates that a high protein content of wheat has a negative impact on the price margin between bread and feed wheat. A high percentage of wheat that does not meet the falling number threshold of bread wheat and a high demand of bread wheat together cause lower price premiums.

– Insert Table 2 about here –

All parameters in the long-run price relationship are highly significant and indicate the theoretically expected signs. To study their relative (economic) importance (weight), we calculate the elasticities at the sample means. We find an elasticity of -0.90 for the protein content, 0.06 for the falling number and 0.14 for the wheat demand for human consumption; thus, a relative change in the protein content most significantly affects the price margin. If we consider the standard deviations of the independent variables in the sample (see Table 1), the absolute magnitude falling number effect dominates (7.69 = 0.53 * 14.5) over the protein content (-2.79) and the demand (1.53).

The falling number further affects the seasonal pattern (seasonal trend) of the margin. The price premium in general is decreasing over the season, and this negative trend is stronger for years with a higher falling number (percentage of wheat not meeting the falling number threshold of bread wheat quality). For the average falling number (15.5 percent), the decline of the price premium over an entire season is about 10 Euros per ton. A falling number of 30 percent causes a drop of 20 Euro per ton. The falling number has a positive impact on the average (annual) price premium and a negative effect on the trend. In Figure 6 we illustrate the compound effect for the two levels of the falling number, $Z_t^2 = 15.5$ percent and $Z_t^2 =$ 30 percent, respectively. The price premium in seasons with a higher falling number starts at a higher level and drops faster during the season. In week 40 the countervailing forces of the two parameters level out (see Figure 6).

The short run dynamics are mostly insignificant except for the first lags. Significant error correction only appears in the direction of the bread wheat prices. Thus, feed wheat prices are weakly exogenous. As many different factors such as corn, barley, soybean prices, etc. influence the feed wheat price and because many of these factors are likely to be exogenous with respect to the price of (bread) wheat, the causal direction between bread and feed wheat is expected. Although the error correction process is statistically significant, the dynamic adjustments run rather slow. A complete adjustment of the bread wheat price following a shock in the price of feed wheat takes about 40 weeks.[18]

To illustrate the goodness of fit of the VECM-MGARCH model, we run a simple OLS estimation of the ECM specification assuming the feed wheat price to be independent as indicated by the VECM. This model results in an R^2 of 0.6, which compared to results for such processes in the literature indicates a good fit.

Analyzing the conditional autocorrelation of squared residual shows that a MGARCH(1,1) specification reveals significant coefficients and leaves no further ARCH effects. The seasonal trend indicates that the variance of the price relationship decreases during the season. Thus, the volatility of the price premium is high in the beginning of the marketing season and drops significantly during the season by about 30 percent, on average. Figure 1 illustrates this feature. While the average price premium is decreasing during the season, its variation measured by the range between the 25–75 percent quartile is also shrinking over the season. Hence, the risk of the price premium is higher at the beginning than at the end of the marketing season.

[18] For the VECM without considering the heteroscedastic error structure we obtain higher values for the parameter of the speed of adjustment back to the long-run relationship. The coefficient is -0,136 for the bread wheat equation and thus, the reduction back to the long-run relationship would only take 8 weeks.

Implications and Conclusions

Seasonal variations of the price premium between bread and feed wheat indicate the potential for profitably adjusting the grain marketing strategy of farmers that harvest (and store) both wheat types. In this paper we estimate the seasonal pattern of quality premiums for wheat on the Northern German market by a vector error correction approach, which accounts for multivariate general autoregressive conditional heteroscedasticity of the error terms. We find a significant negative seasonal trend for the price premium between bread and feed wheat, which is more distinctive in years when weather conditions during the harvest are less favorable and thereby the production of feed wheat is above normal. Low average qualities indicate a shortage of bread wheat and an excess supply of feed wheat at the start of the season. Towards the end of the season, however, the supply of bread wheat is generally higher due to storage, and the price premium decreases. Further, the volatility around the seasonal trend is higher at the beginning of the season than at the end.

Adjusting the marketing strategy by using the information on the seasonal price premium and its determinants could be profitable. If farmers decide to sell wheat at various dates in the season, and if farmers have both qualities in store, bread wheat should be sold first, and feed wheat should be sold last, on average, for given selling dates. This recommendation is more profitable in years with a shorter supply of bread wheat due to unfavorable weather conditions during harvest. However, due to the volatility of the premium, this recommendation should be double-checked at the actual selling date to consider uncertain deviations from the observed seasonal trend. The deviation can offset the recommended temporal sequence of selling bread and feed wheat.

Though we do not explicitly derive information on the optimal selling date, the negative trend of the price premium indicates the convergence of prices for various qualities over the season. Compared to a situation with identical seasonal price patterns for bread and feed wheat, the convergence of prices implies that farmers should sell feed (bread) wheat later (earlier) in the season. To quantify this effect, traditional models simulating optimal wheat marketing strategies would need to consider the estimated seasonal trend in the premium (or the differences in the seasonal patterns of prices), as well as the estimated random deviations of the premium between bread and feed wheat to derive estimated optimal selling dates. We leave this task to future research.

To adjust the marketing strategy in the outlined direction, farmers have to invest in their storage facilities to separately store bread and feed wheat. In addition, they have to apply reliable testing procedures on the farm to separate qualities. In general, quality testing is done on the site of the grain trader when the wheat is delivered. Due to high transaction costs for returning wheat to the farm, delivery implies selling. Further, farmers with forward contracts on bread wheat have to deliver wheat whether the quality meets the requirements or not. If the quality is insufficient, farmers have to accept a deduction that likely covers the price difference between bread and feed wheat and the premium that traders have to pay for buying the bread wheat somewhere else. Thus, farmers should pay attention to the conditions in the contract, particularly during cases of non-performance. To circumvent this problem, farmers may think of substituting forward contracts against future contracts that allow the farmer to reconsider the stockholding decision after the harvest. Future contracts are settled and thus farmers only lose the price premium. There is no need for compensating a trader for buying bread wheat from someone else.

However, increased costs due to the storing of different qualities, the risk involved because of random variations of the price premium, or the time lag in the availability of the required information (e.g. protein content, falling number, demand in the respective season) may prevent a profitable use of the trend in the seasonal price premium.

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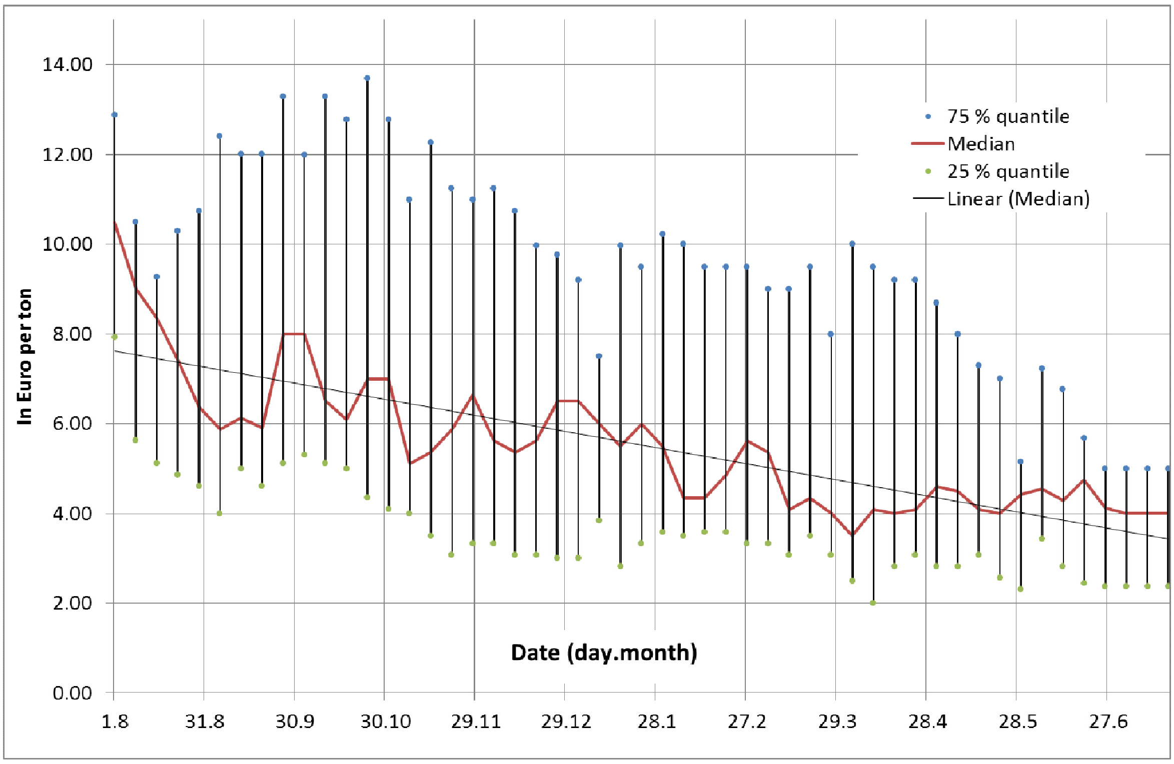
Figures and Tables

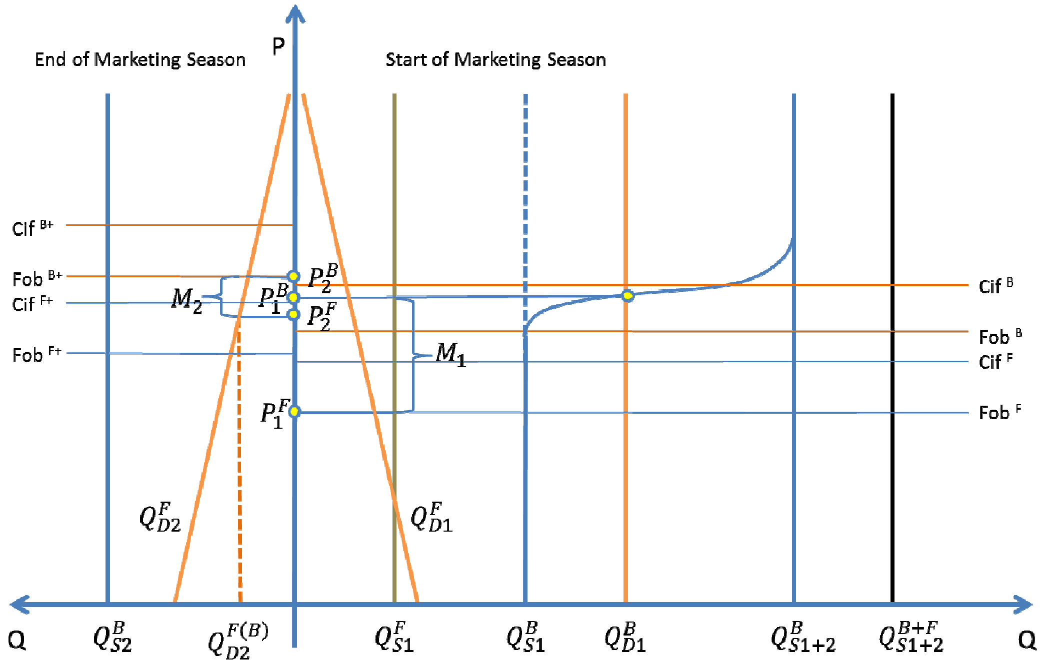
Figure 1: Average price premium for wheat during the marketing season from 1994 to 2011 $\phi(P^B\text{-}P^F)$



Legend: Price premium = price for bread wheat – price for feed wheat. Linear: linear trend for the median.

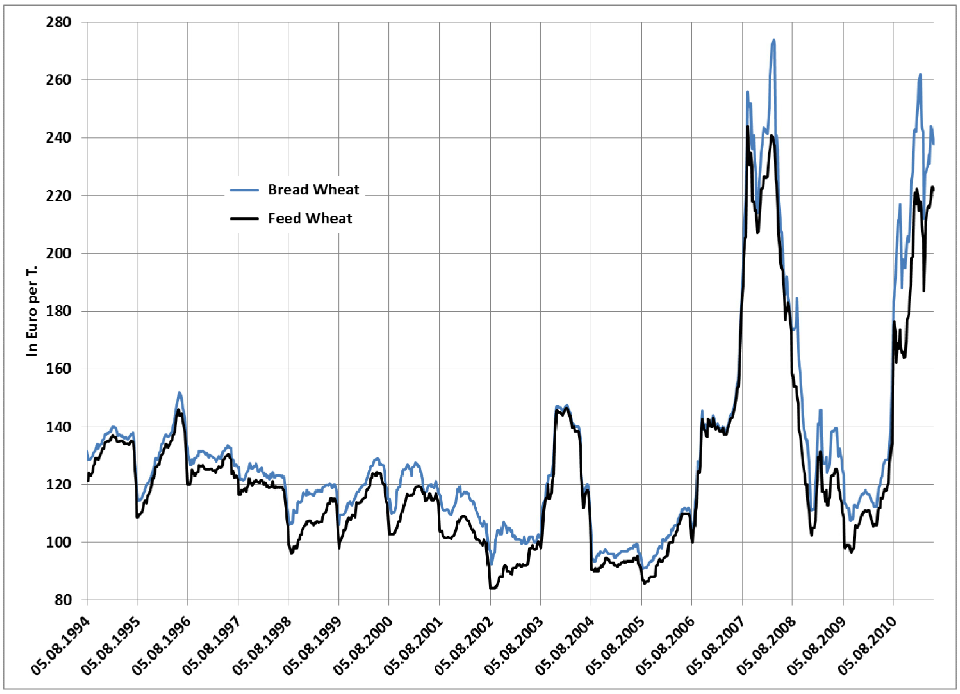
Source: Own calculations based on data from Landwirtschaftskammer Schleswig-Holstein (2012).

Figure 2: Seasonal model of the German wheat market



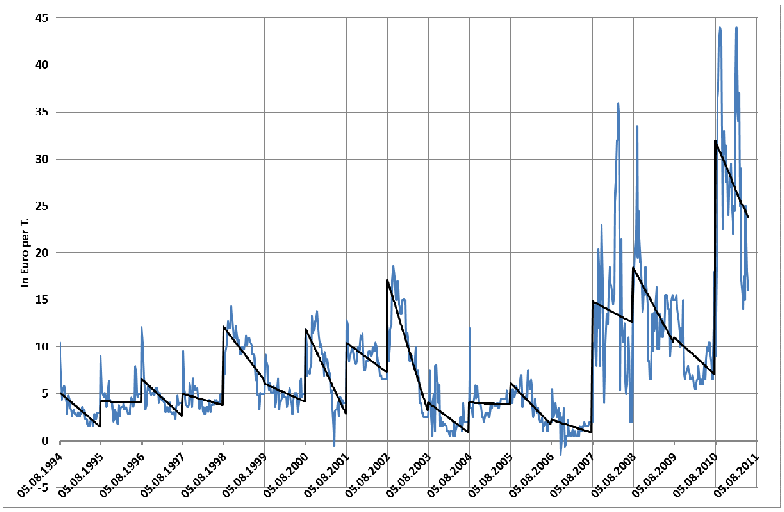
Legend: B/F: Bread wheat/feed wheat. S: Supply. D: Demand. P: Price. Q: Quantity. M: Quality Price Premium (Margin) = P^B-P^F. 1/2: First period or start of the season/second period or end of the season. The + indicates the price increase over the season due to storage costs.

Figure 3: Producer prices of bread and feed wheat from 1994 to 2011 (P^B, P^F)



Source: Own calculations based on data from Landwirtschaftskammer Schleswig-Holstein (2012).

Figure 4: Price premium for wheat from 1994 to 2011 (P^B-P^F)



Legend: Price premium = price for bread wheat – price for feed wheat (blue line). For this series, we estimate a linear trend for each season separately (solid black line).

Source: Own calculations based on data from Landwirtschaftskammer Schleswig-Holstein (2012).

Table 1: Descriptive Statistics

Price Series		Unit	Mean	Std. Dev.	Min.	Max.
Bread Wheat	(P_t^B)	(€/mt)	132.7	35.9	91.0	274.0
Feed Wheat	(P_t^F)	(€/mt)	125.0	32.4	84.1	244.0
Quality Price Premium		(€/mt)	7.6	6.9	-1.5	44.0
Quality Characteristics						
Protein Content	(z_t^1)	(percent)	13.0	0.3	12.4	13.5
Falling Number	(z_t^2)	(percent)	15.5	14.5	1.5	54.0
Consumption of BW	(z_t^3)	(mio. mt)	6.178	0.515	5.349	7.364

Legend: Number of observations for the price series is 905.
Source: Own calculations, data from Landwirtschaftskammer Schleswig-Holstein (2012); AMI, various issues; MRI, various issues.

Table 2: Estimation results for the VECM MGARCH(1,1) model

Co-integrating relationship:

$$\underset{}{P_t^B} = \underset{(24.76)}{92.24^{***}} + \underset{(0.02)}{1.12^{***}}P_t^F \underset{(1.77)}{-9.30^{***}}Z_t^1 + \underset{(0.06)}{0.53^{***}}Z_t^2 + \underset{(1,03)}{2.96^{***}}Z_t^3 - \underset{(0.002)}{0.013^{***}}ST_t \cdot Z_t^2$$

Short-run dynamic parameters: $\begin{pmatrix} \Delta P_t^B \\ \Delta P_t^F \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} ECT_{t-1} + \sum_{i=1}^{6} \begin{pmatrix} \gamma_{i11} & \gamma_{i21} \\ \gamma_{i21} & \gamma_{i22} \end{pmatrix} \begin{pmatrix} \Delta P_{t-i}^B \\ \Delta P_{t-i}^F \end{pmatrix}$

VECM-MGARCH(1,1)

	Equation 1 (bread wheat)	**Equation 2 (feed wheat)**
α_j	-0.0240 (0.0089) ***	0.0110 (0.0090)
γ_{11j}	0.1250 (0.0460)***	0.2723 (0.0504)***
γ_{21j}	-0.0008 (0.0395)	0.1053 (0.0380)***
γ_{31j}	-0.0250 (0.0357)	0.0320 (0.0318)
γ_{41j}	-0.0283 (0.0407)	-0.0398 (0.0387)
γ_{51j}	0.0194 (0.0359)	0.0430 (0.0332)
γ_{61j}	-0.0026 (0.0285)	0.0197 (0.0230)
γ_{12j}	0.1668 (0.0456)***	0.0224 (0.0360)
γ_{22j}	0.0567 (0.0424)	-0.0348 (0.0355)
γ_{32j}	0.0853 (0.0294)***	0.0120 (0.0300)
γ_{42j}	0.0155 (0.0360)	-0.0168 (0.0324)
γ_{52j}	0.0160 (0.0254)	-0.0014 (0.0270)
γ_{62j}	-0.0154 (0.0231)	-0.0094 (0.0250)

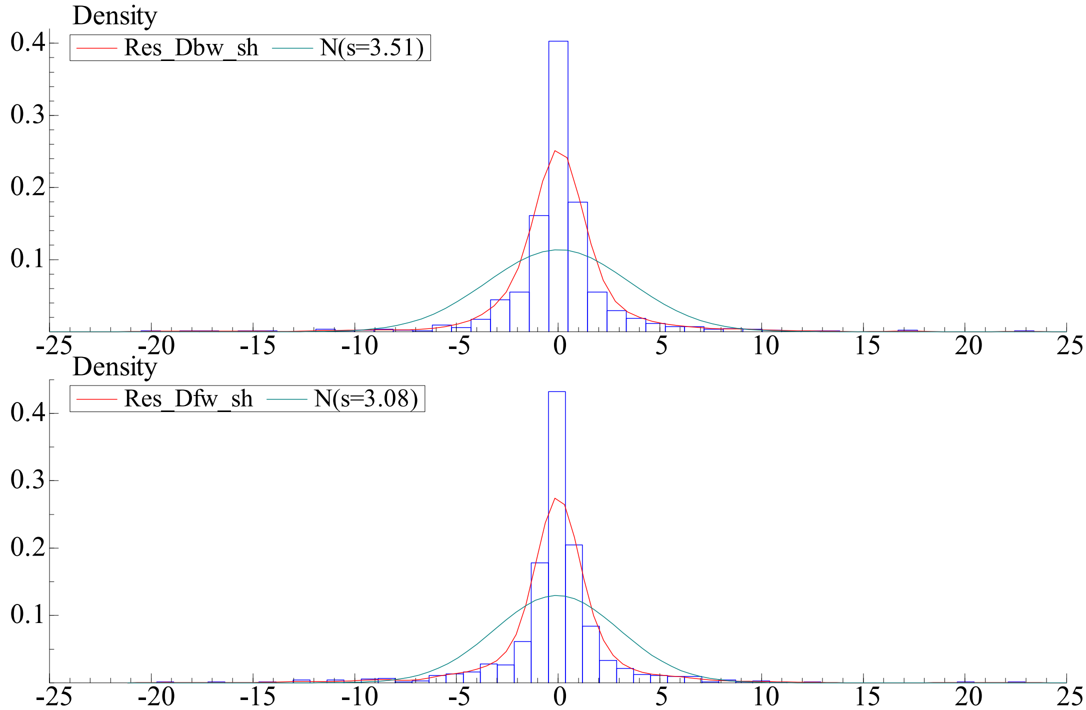
GARCH model parameters: $C = \begin{pmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{pmatrix};\ A = \begin{pmatrix} a_{11} & 0 \\ 0 & a_{22} \end{pmatrix};\ B = \begin{pmatrix} b_{11} & 0 \\ 0 & b_{22} \end{pmatrix}$

	Equation 1 (bread wheat)	**Equation 2 (feed wheat)**
c_j	0.1510 (0.1687)	
c_j	-0.2829 (0.2224)	0.0000 (0.0000)
a_{jj}	0.4093 (0.0540)***	0.5150 (0.0964)***
b_{jj}	0.9124 (0.0193)***	0.8571 (0.0647)***
ST	-0.1011 (0.0168)***	-0.1222 (0.0204)***

Log-likelihood = -3086.14

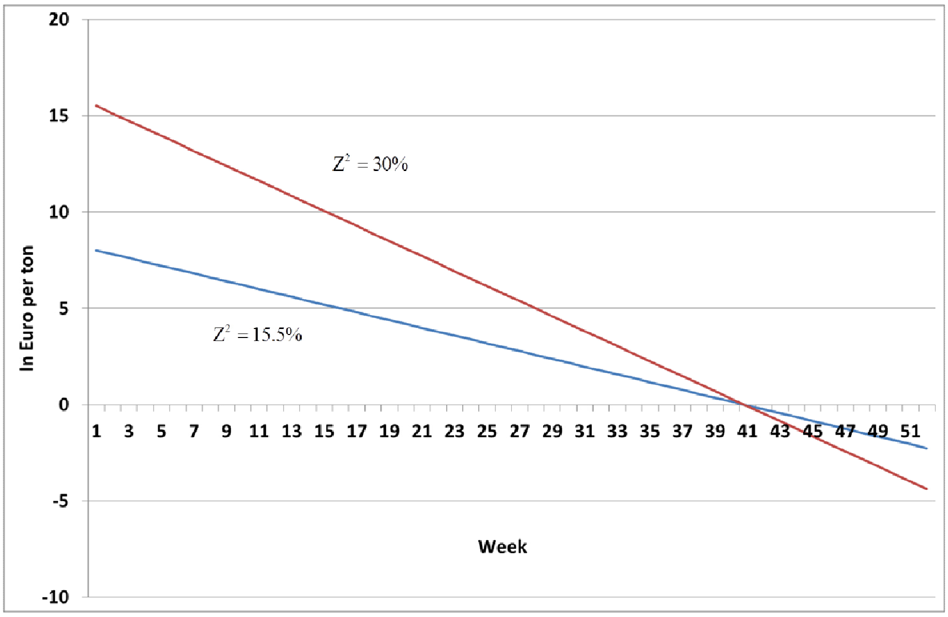
Legend: *** (**, *) significant at 1 (5, 10) percent level. Standard errors are in parentheses.
Source: Own calculations using GRETL 1.97 and PcGive 13.2 and GARCH-PcGive 2.0 (see Cottrell A. and R. Lucchetti, 2007 and Doornik and Hendry, 2011). Data from Landwirtschaftskammer Schleswig-Holstein (2012); AMI, various issues; MRI, various issues.

Figure 5: Distribution of errors of the VECM MGARCH(1,1) model



Source: Own calculations using PCGIVE 10.0 (Doornik and Hendry, 2011). Data from Landwirtschaftskammer Schleswig-Holstein (2012); AMI, various issues; MRI, various issues.

Figure 6: Compound dynamic effect that falling number (Z^2) has on the price premium



Legend: Z^2: Falling number (the percentage of samples taken during harvest in the region (Northern Germany) that fail to match the falling number criterion of bread wheat).

Source: Own calcualtions.